COMMONWEALTH BUREAU OF
HORTICULTURE AND PLANTATION CROPS*

TECHNICAL COMMUNICATION No. 19

SEED PRODUCTION OF EUROPEAN VEGETABLES IN THE TROPICS

By

A. G. G. HILL, B.A., B.Agr., B.Sc., A.R.C.Sc.I.

*Known as the Imperial Bureau of Horticulture and Plantation Crops prior to January, 1948

CONTENTS

PAGE

FOREWORD. By Mr. F. R. Horne, M.A., N.D.A., N.D.D.(Hons.), Director of the National Institute of Agricultural Botany, Cambridge 3

PREFACE 4

QUESTIONNAIRE ON SEED PRODUCTION OF EUROPEAN VEGETABLES IN THE TROPICS ISSUED BY THE IMPERIAL BUREAU OF HORTICULTURE AND PLANTATION CROPS 5

A SUMMARY OF REPLIES TO THE QUESTIONNAIRE, WITH SOME OBSERVATIONS 6

SOME CONCLUSIONS 15

BIBLIOGRAPHY 16

APPENDIX I. Some temperate region vegetable varieties grown in various tropical countries 18

APPENDIX II. A selection of indigenous and naturalized plants used as vegetables in various tropical countries 21

APPENDIX III. Meteorological data 26

APPENDIX IV. List of countries to which questionnaire was sent 28

ACKNOWLEDGMENTS 28

FOREWORD

The high nutritive value of many of the species grown as vegetables makes it desirable to encourage their cultivation on an adequate scale both in European and tropical countries. The yield and quality of vegetable crops depend largely on the suitability of seed stocks, and it is very appropriate that this aspect should have been investigated in relation to conditions in the tropics.

The first interest of those who grow seed crops is naturally to supply vegetable growers in the same or adjoining regions, but the production of seed for export is being considered in several tropical countries and is already established in some areas.

The use of European vegetables in the tropics raises the question as to what changes in genetic constitution are necessary to suit these new conditions. In some cases new varieties are needed which react quite differently to the length of day and range of temperatures ; potatoes, though not strictly vegetables, provide instances of European varieties unsuited in their present form to tropical conditions. In this case it is necessary for plant breeders to study a wide range of varieties and species and from these to develop suitable new hybrids.

In other cases European vegetables appear to be unsuited to growing conditions in the tropics, and it might be better to devote plant breeding facilities to alternative tropical species.

After certain varieties of vegetables have proved suitable it is necessary to arrange for the production of regular supplies of seed and this involves different considerations from the growing of vegetable crops.

If the variety is one already being grown in Britain or another European country with a flourishing seed industry, it may be most satisfactory to trust the vital stages of selecting mother stocks and roguing commercial seed crops to specialists already familiar with it. When new varieties of European vegetables have to be specially selected to suit tropical conditions it is necessary, at least, to maintain mother stocks and there is much in favour of multiplying these in a tropical environment when this is practicable.

The regular hours of sunshine, coupled with low humidity, provide attractive conditions for seed growing and prompt the question whether better and cheaper seeds for use in Europe might, in some cases, be grown in tropical countries ; dwarf beans furnish an instance of seed crops which can be grown very successfully in certain parts of East Africa.

To plant breeders trying to build up stocks of new varieties the possibility of obtaining, in one season, a seed crop of biennials or two successive crops of annuals may be of special value.

The investigation of which this bulletin forms a record was summarized by Mr. A. G. G. Hill who, from his intimate knowledge of conditions in East Africa, is particularly well qualified to undertake this task ; it supplies an answer to many questions which have been raised, and indicates lines on which research work should be undertaken.

F. R. HORNE.

March, 1948.

PREFACE

In July, 1939, this Bureau was asked by the Director of the East African Agricultural Research Station to make enquiries into the methods used for producing seed of so-called European, or temperate region, vegetables in the tropics, particularly in highland areas. The results of that enquiry, which were incorporated in an article published in the *East African Agricultural Journal* for May, 1940 (19), showed that extremely little was known on the subject. With the spread of the war and the cutting off of many normal sources of seed supply, increased interest was shown in the possibility of producing seed of European vegetables in tropical highlands for the supply of local needs, and also as a possible source of seed for the United Kingdom and other allied countries deprived of their usual supplies. The scarcity of exact knowledge on the subject, which was brought out in the above article, was further emphasized by a second article in the same journal in July, 1942 (20), and again one year later, in *Joint Publication No. 5 of the Imperial Agricultural Bureaux* (32). Meanwhile, under the stimulus of war, a joint scheme for the production of European vegetable seed had been started in mid-1942, in East Africa, where a seed specialist was subsequently appointed by the governments of Kenya, Tanganyika and Uganda. As a result, considerable progress was made in East Africa, but, even so, many problems remained unsolved (17). This fact, together with lack of information on the progress being made in other parts of the tropics led the East African Standing Agricultural Research Committee to ask the Imperial Bureau of Horticulture and Plantation Crops to issue a questionnaire with the object of eliciting certain pertinent facts from different parts of the tropics which might separately and together throw light on existing problems. The summary of forty-three replies to this questionnaire which was sent out in October, 1944, is given in the following pages, together with some additional information derived from other sources.

The information received in the replies from northern India, Palestine, Cyprus and Bermuda has not been included in this communication as these countries are outside the tropics. Considerable progress was made in vegetable seed production in northern India and Palestine during the war.

QUESTIONNAIRE ON SEED PRODUCTION OF EUROPEAN VEGETABLES IN THE TROPICS

issued by

THE IMPERIAL BUREAU OF HORTICULTURE AND PLANTATION CROPS

(*a*) i. What kinds and varieties of vegetables of temperate origin are grown locally ?
ii. How many years they have been grown continuously in the tropics from original imported seed ?
iii. What methods are employed in acclimatizing them ?
iv. Have they improved or deteriorated ?
v. What varieties, or strains have been developed locally ?

(*b*) i. What is the history of local efforts to produce vegetable seed ?
ii. Is there any organization or Government Department responsible for the work ?
iii. To what extent is commercial production undertaken ?

(*c*) What is the local demand for seed of European vegetables and potatoes by Europeans and others ? Is there any export demand ?

(*d*) i. What are the localities and altitudes at which vegetable seed growing is undertaken ?
ii. What are the usual growing and harvesting dates for each variety ?
iii. What are the mean monthly maxima, minima and daily ranges of temperature, mean monthly totals of rain and mean monthly number of " wet days " ?

(*e*) Is there any local evidence that long-day plants will not flower in the tropics, even when given a sufficiently low temperature at a critical stage of development? (A list of kinds and varieties which have not been known to flower, apparently owing to shortness of day, would be of value.)

(*f*) Have any vernalization or " cold-spell " experiments been carried out with seedlings or older plants ? Does vernalization produce mutations or indications of physiological abnormality ?

(*g*) What evidence can be produced to support the theory that degeneration of temperate vegetables in the tropics is due to physiological causes and not to contamination by uncontrolled crossing or disease ?

(*h*) i. What indigenous vegetables are of value ?
ii. To what extent are they used by Europeans and natives respectively ?
iii. Are there any facts or theories regarding the possibilities of crossing indigenous and temperate vegetables, with the object of improving tropical crops ?

(*i*) What are the pollen-carrying agents in each locality? What controls and precautions are necessary as compared with practice in Great Britain?

(*j*) Have sterility and poor fertilization been observed in the field, e.g. in brassicas and celery ? Is there any explanation of, or remedy for, this ?

(*k*) i. What kinds of machinery are used for cleaning seeds ?
ii. How are seeds of lettuce and carrot dealt with ? What is the shape and size of screen aperture used for each kind of seed ?

(*l*) Are dressings, chemical or organic, used ? What is their effect on germination, especially mercuric dressings used on seeds stored in humid climates.

(*m*) How are roots stored ? What method of selecting and transplanting roots is followed when storage is impracticable ? Is difficulty experienced in storing potatoes (*Solanum*) and what is the best method of storage ?

(*n*) i. How are seeds stored and packed ?
ii. What are the after-ripening period (maturation) and viability (longevity) of seeds stored in various kinds of containers and at specific temperature and humidities ?

(*o*) i. Are germination tests and field trials carried out under qualified supervision ?
ii. What are the methods and standards ?

(*p*) i. Are there regulations controlling seed production ?
ii. How and to what extent are they enforced ?
iii. How have they affected the standard and quantity of production and trade ?

A summary of replies to the questionnaire, with some observations.

(*a*) **QUESTION**

i. What kinds and varieties of vegetables of temperate origin are grown locally ?
ii. How many years they have been grown continuously in the tropics from original imported seed ?
iii. What methods are employed in acclimatizing them ?
iv. Have they improved or deteriorated ?
v. What varieties, or strains have been developed locally ?
vi. What are their parentage and characteristics ?

(*a*) **REPLY**

i. The 43 replies to this question show that, given sufficient water, manure, care and protection, most of the common European vegetables can be grown in the tropics, at least during the cooler months, and all the year round in the tropical highlands. The quality of the vegetables grown, however, is not always up to standard, e.g. lettuce grown under tropical conditions lacks crispness and often fails to form a heart. Amongst the more difficult kinds of vegetables to grow in the tropics are : broad beans, globe artichokes and asparagus. One temperate vegetable, the scarlet runner bean, appears to be a failure in most parts of the tropics, but there are records of it being grown in Mauritius, St. Helena and Tanganyika. For a list of varieties of temperate vegetables grown in various tropical countries, see Appendix I. Early varieties usually do best.
ii. Excepting during the war years, 1939-45, there are few records of European vegetables having been grown continuously in the tropics from locally-produced seed. In most tropical countries it is the general practice to import all seed required from temperate

regions at frequent intervals. There are, however, a few interesting exceptions to this general practice : thus in Mauritius, parts of India and the Cameroons it has been customary for years past to save seed of certain European vegetables. The war stimulated efforts to produce seed locally and there are records of such seed being produced in commercial quantities in several parts of the tropics during the war, notably in the East African territories, Mauritius, Ceylon and Nigeria (see v. and vi. below).

iii. The only full account of an attempt to acclimatize temperate region vegetables in the tropics comes from Kenya where the Seed Specialist tried the following method, with what result is not yet known. (*a*) The first generation of vegetables was grown in the district most nearly approaching the ideal climate, usually at over 7,000 ft. above sea level. (*b*) If they failed to flower there, some of the mature plants were then transferred to even higher elevations, up to 10,000 ft. above sea level. (*c*) The seed, if any, from these plants was sown in various localities, including some at lower altitudes. (*d*) The plants from this seed were rogued severely, leaving only the most satisfactory plants. The intention was to introduce the progeny to successively lower and drier areas and thus, it was hoped, overcome by gradual acclimatization their inability to flower and reproduce by seed, except under the coolest conditions. Difficulty was experienced in getting cabbage, carrot, beet and celery to flower, except at high elevations (9,000-10,000 ft.).

iv. The general opinion expressed is that most temperate vegetables do deteriorate in the tropics. As against this must be set such replies as the following. Madura, Madras : here beans, carrots, cauliflower, lettuce, parsnip and tomato appear not to have deteriorated. Mauritius : no deterioration of beans, cauliflower, French turnip, lettuce and onion was observed, given proper attention. Mignonette lettuce introduced many years ago is still good. Kisumu, Kenya (2,300 ft. above sea level) : carrots show little deterioration in the fourth generation, except when native grown. The common belief that all temperate vegetables deteriorate in the tropics is probably based on the knowledge that seed is apt to lose vitality as the result of faulty storage conditions adopted owing to ignorance (23).

v. *and* vi. Remarkably few local strains of temperate region vegetables have been developed in the tropics, even where such vegetables have been grown for many years. According to the replies received, the only local strains which have been developed are :—Ceylon : strains of beans, peas and vegetable marrow. Nilgiris : strains of non-bolting cauliflower. Mauritius : strains of several vegetables have been evolved by local market-gardeners, e.g. local selections of Le Norman and Alger cauliflower, petit pois and French turnip. Hawaii : strains of improved mustard and tomato resistant to spotted wilt. Cameroons : a strain of cabbage (Santa) and an onion variety descended from an introduction of over thirty years ago.

(*b*) **QUESTION**

i. What is the history of local efforts to produce vegetable seed ?
ii. Is there any organization or Government Department responsible for the work ?
iii. To what extent is commercial production undertaken ?

(*b*) **REPLY**

i. Except in East Africa and parts of India no plans appear to have been made in the tropics to produce seed of temperate vegetables in commercial quantities. There are a few countries, e.g. Mauritius, where seed of a limited range of temperate vegetables has been produced in small quantities for years past by market-gardeners for their own use. Local varieties of this sort deserve to be tried elsewhere in the tropics.

ii. In most tropical countries the local agricultural department is the only available body for organizing the production of vegetable seeds, and during the war many of these departments undertook vegetable seed production, though usually on a very small

scale. The only records of comparatively large-scale production come from India and East Africa. Thus in India government sponsored projects for seed production were established in the Nilgiris, Madras, as well as in Baluchistan, Kashmir and the Punjab, outside the tropics. In East Africa the agricultural departments of Kenya, Tanganyika and Uganda established a joint scheme in 1942 to produce vegetable seed, mainly for local needs, a Seed Specialist being appointed in February, 1943, with headquarters at Turi in Kenya. A small seed station for temperate region vegetables was opened at Ambawela, Ceylon, in 1944.

iii. Outside East Africa and South India there is apparently no commercial production of temperate vegetable seed in the tropics. In the Arusha district of Tanganyika, East Africa, high-grade bean seed has been raised and exported annually for years past, the production in 1945 being approximately 1,000 tons.

(*c*) **QUESTION**

i. What is the local demand for seed of European vegetables and potatoes by Europeans and others ?

ii. Is there any export demand ?

(*c*) **REPLY**

i. The demand for temperate vegetable seed and for seed-potatoes in most parts of the tropics is relatively small and generally related to the number of residents of European stock, since local inhabitants usually prefer their own tropical vegetables. There are exceptions to this generalization : thus India, including the tropical south, is thought to use about 1½ million lb. of temperate vegetable seed per annum, of which the great bulk is derived from Indian sources. In East Africa a tentative figure of £15,000 is quoted as the value of temperate vegetable seed used in 1944. Certain of the British West Indian islands import comparatively large quantities of temperate vegetable seed. In some African territories there is a growing demand from the native and Indian populations for certain kinds of temperate vegetables, particularly cabbage, carrots and peas. In no tropical country is there a big demand for imported seed-potatoes.

ii. In East Africa there is a demand from United Kingdom merchants for seed of beans, cauliflower, cucumber, lettuce, marrow, radish and tomato. Elsewhere in the tropics no demand is reported.

(*d*) **QUESTION**

i. What are the localities and altitudes at which vegetable seed growing is undertaken ?

ii. What are the usual sowing and harvesting dates for each variety ?

iii. What are the mean monthly maxima, minima and daily ranges of temperature, mean monthly totals of rain and mean monthly number of " wet days " ?

(*d*) **REPLY**

i. The answers to questions (*d*) i. and (*d*) ii. are tabulated opposite. They clearly indicate
and the rapidity with which some temperate region vegetables, notably biennials, form
ii. seed in certain favoured parts of the tropics (17).

iii. Meteorological data for three areas in the tropics where seed of European vegetables is successfully produced are given in tabular form in Appendix III.

(*e*) **QUESTION**

Is there any local evidence that long-day plants will not flower in the tropics, even when given a sufficiently low temperature at a critical stage of development ? (A list of kinds and varieties which have not been known to flower, apparently owing to shortness of day, would be of value.)

A List of Seed-Growing Districts in the Tropics.

Country.	District.	Elevation above sea level approx.	Latitude approx.	Date of sowing.	Date of seed harvest.
Ceylon	Nuwara Eliya	6,000 feet	7°N	No exact dates given for Ceylon, but the following are quoted as periods from sowing to harvesting :— Cabbage 9-12 months or more ; Cauliflower 11-14 months ; Carrot and beetroot 11-15 months ; Lettuce and tomato 5-6 months.	
East Africa	Mau, Kenya	7,000-10,000	on equator	In East Africa sowing and harvesting dates vary with district. Most brassicas and roots are sown at the beginning of the long rains, while beans, cucurbits, lettuce, peas and tomatoes are sown towards the end of these rains. Vegetative maturity (fit for market) arrives very rapidly but this usually bears no apparent relation to the time taken to flower and seed.	
,, ,,	Kinangop, Kenya	8,500-9,000	1°S		
,, ,,	Endebess, Kenya	7,000-8,000	1°N		
,, ,,	Kitale, Kenya	6,000	1°N		
,, ,,	Subukia, Kenya	6,000	1°N		
,, ,,	Arusha, Tanganyika	4,000-7,000	3½°S		
,, ,,	Moshi, Tanganyika	2,900-5,000	3½°S		
,, ,,	Mbulu, Tanganyika	6,000-7,000	4°S		
,, ,,	Lushoto, Tanganyika	4,500-5,000	5°S		
India, S.	Ootacamund	7,000-7,500	11½°N	Biennials, Aug.-Sept.	After 8 months
Mauritius	Réduit	900	20°S	Cauliflower, March	,, 8 ,,
,,	,,	,,	,,	Radish, June	,, 5 ,,
,,	,,	,,	,,	Parsley, June	,, 7 ,,
,,	Pamplemousses	180	20°S	Lettuce, April	,, 7 ,,
,,	,,	,,	,,	Carrot, April	,, 10 ,,
,,	,,	,,	,,	Tomato, April	,, 8 ,,
Nigeria	Santa Cameroons	6,000	6°N		
,,	Bambui, Cameroons	4,800	6°N	Beans and Peas, Sept.	,, 4 ,,
,,	,, ,,	,,	,,	Cabbage, Dec.	,, 14 ,,
,,	,, ,,	,,	,,	Carrot, March-April	,, 10-11 ,,
,,	,, ,,	,,	,,	Leeks, October	,, 16 ,,
,,	,, ,,	,,	,,	Lettuce, January	,, 7 ,,
,,	,, ,,	,,	,,	Onions, June	,, 9 ,,
,,	,, ,,	,,	,,	Radish, July	,, 7-8 ,,
,,	,, ,,	,,	,,	Tomatoes, April	,, 7 ,,
,,	,, ,,	,,	,,		

(*e*) REPLY

The replies to this question indicate that the following vegetables do not normally flower in the tropics at low elevations :—beet, broad beans, cabbage, celery, cauliflower (temperate varieties), kale, kohlrabi, onions (except short-day kinds), leeks, parsley, scarlet runner beans, spinach-beet and turnips. In the East African highlands, where many temperate vegetables set seed even on the equator, it is reported that brussels sprouts, cabbage (particularly early varieties), curly kale, most non-tropical onions and leeks are " shy to flower " even at 7,000 ft. above sea level, but that all temperate vegetables, including long-day kinds, can be induced to flower and set seed by growing them at higher altitudes (up to 10,000 ft. above sea level) (see (*f*) below). Although the quantity of seed thus produced is often negligible the result is of interest as showing that the short-day factor is not wholly responsible for the failure of certain temperate vegetables to flower and set seed in the tropics (1), (25), and that its importance may hitherto have been exaggerated. Certain flowers can also be induced to bloom by growing them at higher elevations, e.g. *Lathyrus latifolius* and Geum which, according to one observer, failed to flower in Kenya at 5,500 ft. above sea level, but did so when planted at over 9,000 ft. above sea level.

(*f*) QUESTION

Have any vernalization or " cold-spell " experiments been carried out with seedlings or older plants ? Does vernalization produce mutations or indications of physiological abnormality ?

(*f*) REPLY

The only reported cold-spell experiments with temperate vegetables in the tropics come from Kenya and Mauritius, the latter experiments not being a success. In Kenya a number of growing vegetable crops were subjected to natural cold-spells, either by sowing them at a high altitude, timing the sowings so that vegetative maturity was reached during the coldest part of the year, or by transplanting them from a relatively hot area to a colder one (see (*e*) above). Two types of cold-spell are experienced in the Kenya highlands, (1) the cold, but frost-free, long-rains of about three months, and (2) the radiation frosts on clear nights during the hot, dry season, December to February. Type (1) was found to induce flowering in vegetables far more than does type (2), even though in the latter case irrigation water is supplied to make up for any lack of rain. The cold, long-rains is a season of dull, overcast skies and it is interesting to speculate, writes Hawkins, to what extent this affects the already short day of about 12 hours. Again, does the reduced transpiration of the plant at this season assist flower initiation?

(*g*) QUESTION

What evidence can be produced to support the theory that degeneration of temperate vegetables in the tropics is due to physiological causes and not to contamination by uncontrolled crossing or disease ?

(*g*) REPLY

There is no conclusive evidence from the replies to support the theory that degeneration is due to physiological causes rather than to contamination by uncontrolled crossing, disease or other factors. That degeneration does take place is generally agreed, and this is variously attributed to one or more of the following factors : lack of plant selection, failure to rogue off-types, contamination by uncontrolled crossing, diseases and pests, bad management, drought, inadequate drying and bad storage of seed. The degeneration which takes place in the tropics in potato stocks, where no crossing takes place, is very probably caused by virus disease and, to a lesser extent, by drought and

mismanagement. Another suggested cause is the practice of planting seed-potatoes a short time after harvest so that they have no resting period—a usual expedient in the tropics where, owing to high temperatures, seed-potatoes can be stored for only a comparatively short time. None of the replies refer to the possibility of storing potato seed in the form of dried eyes or chips (9). What appear to be physiological reactions to climate have been observed by Hawkins and Jackson in the Kenya highlands in individual generations of such crops as carrots, where by growing them too early in the cold, wet-season they are induced to form long, pale, and sometimes purple-tinted, roots. The same observers noted that carrots, turnips and beet grown in hotter, though moist, conditions, tend to develop giant forms which are pithy and hollow. None of these abnormalities appeared to be inherited.

(*h*) QUESTION

i. What indigenous vegetables are of value ?
ii. To what extent are they used by Europeans and Natives respectively ?
iii. Are there any facts or theories regarding the possibilities of crossing indigenous and temperate vegetables, with the object of improving tropical crops ?

(*h*) REPLY

i. The sum total of indigenous and naturalized vegetables, wild and cultivated, which are used in different parts of the tropics is great and far exceeds the number of vegetables used in temperate regions. Most of these vegetables are of the leafy type and many of them are no more than pot-herbs. There is a noticeable lack of root vegetables such as the beets, carrots, parsnips and turnips of temperate regions. A selected list of indigenous and naturalized plants used as vegetables in different parts of the tropics is given in Appendix II. The kinds of vegetable grown in the tropics show differences as between Africa, India and the Far East. Thus in tropical Africa one does not find the cultivated *Cruciferae* which are popular in China and to a certain extent in India. This lack however, is compensated to a large extent by the wealth of wild spinach plants in Africa. Much has still to be learnt about these plants, all of which could probably be vastly improved by cultivation and selection (21).
ii. Europeans living in the tropics, do not, as a rule, use the indigenous vegetables as much as they might do to their profit. This is mainly due to conservatism and ignorance of the identity and possibilities of local vegetables. A contributory cause is ignorance of the special cooking required by some tropical vegetables.
iii. Since the indigenous and naturalized vegetables of the tropics do not for the most part belong to the same genera as temperate region vegetables, it is generally impossible to use them in the improvement by breeding of temperate vegetables, except possibly of peas, beans and cucurbits, among which are found tropical kinds with drought- and disease-resistant qualities, often lacking in temperate varieties. On the other hand temperate varieties of cucurbits might well be used in plant-breeding to introduce better eating qualities into tropical kinds, many of which are coarse and flavourless by European standards. This question of quality is not so simple as it might appear. For instance, whereas the European looks for tenderness in his culinary peas and beans, the African, who does not eat these vegetables green, judges his pulse varieties mainly by the storing and eating qualities of the ripe seed.
What is needed from the standpoint of the dweller in the tropics is the improvement by selection and breeding of his indigenous and acclimatized vegetables rather than the importation of improved varieties from abroad.

(*i*) QUESTION

What are the pollen-carrying agents in each locality ? What controls and precautions are necessary as compared with practice in Great Britain ?

(*i*) REPLY

Knowledge of the pollen-carrying agents of temperate vegetables in the tropics is notably lacking. No exact work appears to have been done on the subject but observations suggest that the main pollinating agents are the same as those operating elsewhere, insects and wind. In East Africa, which is one of the few regions in the tropics where the production of temperate vegetable seed has been undertaken on any considerable scale, growers have been recommended to adopt the following minimum planting distances, some of which probably err on the safe side, a desirable precaution in East Africa where insect life is abundant and high winds are frequent (15), (16), (34), (35).
Cabbage family. This is divided into three chromosome groups (11). Crossing is common within a group, and a small amount of hybridizing may occur between groups. The minimum recommended distance between kinds within a group is two miles and the distance between kinds in different groups, 220 yards.
Pea and bean family. Garden and field peas and broad beans, between varieties, 300 yards ; runner beans, from dwarf beans and other runner varieties 200 yards ; dwarf beans, between varieties 50 yards ; dwarf beans, from runner beans, 200 yards.
Umbelliferae. Carrots, parsnips and parsley, between varieties 1,200 yards ; celery, between varieties and from celeriac 1,200 yards ; celeriac, between varieties and from celery 1,200 yards.
Cucurbits. Between kinds and varieties 300 yards.
Miscellaneous. Lettuce, endive and tomatoes, between varieties, 100 yards. Beetroot and chard, between kinds and varieties 1,760 yards.

(*j*) QUESTION

Have sterility and poor fertilization been observed in the field, e.g. in brassicas and celery ? Is there any explanation of, or remedy for, this ?

(*j*) REPLY

Although supporting scientific data are lacking, the replies to this question indicate that even in those tropical countries where temperate vegetables flower, various degrees of unexplained sterility and poor fertility are found, possibly due to unfavourable weather, such as prolonged tropical rain, which may affect the flowers directly, or, possibly, indirectly by reducing the activity of pollinating insects. Experience in East Africa suggests that in the Kenya highlands the pollination of brassicas is usually good, provided that there are sufficient plants in the field flowering vigorously and simultaneously. On the other hand small plots of a few plants are often unsatisfactory, especially when the plants are shy or erratic in flowering with perhaps only a few flowers appearing at a time. In such cases artificial assistance would seem to be indicated, unless the species is self-pollinating. Three reports of bad setting of broad bean seed come from Kenya and Nyasaland, without indication of cause. In Kenya the flowers on the lower half of broad bean plants are frequently sterile. No reports of bad setting of celery seed have come to hand from those parts of the tropics where celery flowers.

(*k*) QUESTION

i. What kinds of machinery are used for cleaning seeds ?
ii. How are seeds of lettuce and carrot dealt with ? What is the shape and size of screen aperture used for each kind of seed ?

(*k*) REPLY

i. Apart from Kenya and Tanganyika, in no tropical country to which the questionnaire was sent was seed cleaned by machinery (1945). At Turi Seed Station in Kenya the cleaning and grading plant, erected during the war, include the following :—A Boby

flax seed dresser. A Boby 2-screen seed cleaner with variable blast. A Scourkleen I.H.C. combine attachment. A brushing drum (by Hawkins and Jackson). A flour-mill brushing and sieving cylinder. An air-compressor with pressure cylinder and hose, used for cleaning the plant. This plant is by no means complete for the wide range of seeds treated but its layout allows each machine to be used as a separate unit, a necessary arrangement where small lots of a large number of different kinds have to be dealt with.

ii. The methods used at Turi, Kenya, for dealing with lettuce and carrot seed are as follows : Lettuce seed is harvested, at intervals of a few days, by bending and shaking the ripening heads over canvas stretchers and cleaned by passing it through a Boby 2-screen cleaner one to four times. If the crop is harvested by cutting the heads and then threshing them, a large amount of broken stalk and immature seed becomes mixed with the ripe seed and causes difficulties in cleaning.

Carrot seed is harvested by cutting the umbels when they reach the stage at which about a quarter of their seed can be removed by gently rubbing between finger and thumb. These umbels are sun-dried and then threshed by rubbing them, face down, on a coarse wire-sieve. Drying must not be carried to the stage at which the stalks become brittle and break. The seed-spines are then removed by passing the seed through a brushing drum.

(*l*) QUESTION

Are seed dressings, chemical or organic, used ? What is their effect on germination, especially mercuric dressings used on seeds stored in humid climates ?

(*l*) REPLY

Proprietary seed dressings, such as Semesan, Ceresan, Agrosan and Uspulum are used for vegetable seeds in some tropical countries and have no adverse effect on germination. It is reported from Kenya that, provided seed is not under-ripe or full of moisture, mercuric dressings do not appear to affect germination. In Hawaii, studies to determine the most effective controls for pre-emergence damping-off of seedlings caused by *Pythium* and *Rhizoctonia* spp. have shown the efficacy of Semesan and cuprous oxide (red copper oxide) (40), (41).

(*m*) QUESTION

i. How are roots stored ?
ii. What method of selecting and transplanting roots is followed when storage is impracticable ?
iii. Is difficulty experienced in storing potatoes (*Solanum*) and what is the best method of storage ?

(*m*) REPLY

i. The numerous replies to this question leave no doubt that the storage of roots in the tropics is a serious, and as yet unsolved, problem even in tropical highlands where the climate is temperate. However, since in tropical highlands the growing season can be almost continuous, the problem of storing mother-roots of biennials from one year to the next is avoidable, given sufficient irrigation water, by growing root crops right through to seeding without an intervening storage period.

ii. The following is a description of four methods used in Kenya when selecting carrot mother-roots for seed production.

(*a*) The carrots are uprooted and inspected with a core-sampler, the best in shape and colour being retained. The lower extremity of each carrot is then cut off and the crown partly defoliated, after which the selected roots are transplanted to moist soil, preferably

in wet, dull weather. In Uganda it is reported that the lifting and transplanting of roots for seed production has not proved advantageous.

(*b*) As above, except that up to half of each root is cut away before transplanting.

(*c*) As in (*a*) but using the crown only for transplanting.

(*d*) The carrots are examined *in situ* with the help of a core-sampler, after removing the soil from one side of each row. Selected roots are covered again with soil and left to mature, the rest of the crop being uprooted.

iii. No really satisfactory method of storing potatoes in the tropics has yet been evolved, apart from cold storage at about 40° F. (4·5° C.). Potatoes when properly mature can, however, usually be kept for two to three months if spread out thinly in a dark, dry, airy building, the openings of which should be screened where tuber-moths are troublesome.

Another method for which some success is claimed is storage in dry sand in a cool cellar or similar place. In the Bombay Presidency it is reported that potatoes are stored in the summer by keeping them in beds 20 ft. × 6 ft., covering them with dried grass and spraying this with water. Elsewhere in the tropics the clamping of potatoes would seem to be a failure owing to excessive rotting, shrinkage and sprouting, not to mention the losses caused by termites and rodents. The storage of seed potatoes from one season to the next is usually avoided in the tropics either by obtaining seed from a part of the country where the crop matures at a different time of year, or else by planting a dry-weather, out-of-season, crop in land with a high water-table.

Potato varieties differ in their tendency to sprout in storage, thus in Northern Nigeria, Up-to-Date* is said to be one of the slowest to sprout, a useful quality, except when two crops per annum are wanted. It is also reported from Northern Nigeria that storage is improved and sprouting delayed if the tubers are exposed to light until they become slightly green. The effect of this treatment on eating qualities cannot be good.

(*n*) QUESTION

i. How are seeds stored and packed ?

ii. What are the after-ripening period (maturation) and viability (longevity) of seeds stored in various kinds of containers and at specific temperature and humidities ?

(*n*) REPLY

i. Owing to rapid deterioration of vegetable seeds during storage in the tropics it is usual to import fresh seed at frequent intervals. During the war this was not possible and so arrangements had to be made for local storage. In the case of large quantities the seed was usually kept in cold storage, or in a dry part of the country, or else in highlands where the climate is temperate. The use of calcium chloride desiccators for storing small quantities of seed now seems to be general. Seed can be stored for years in this way, even in the tropics. An interesting method of seed storage is reported from Madras where seeds are mixed with cattle dung, made into cakes and dried slowly by a fire.

Apart from the damage caused during storage by the combination of high humidity, and high temperature, that caused by weevils and other seed pests must also be considered.

ii. Information on the minimum maturation period required by the seed of the different temperate vegetables is not easily obtained (5), (28). In temperate regions vegetable seeds get a resting period of several months after harvest as a matter of course during the winter months, but in the tropics where, given sufficient moisture, plant growth continues throughout the year, seed may be required for sowing shortly after it is harvested, consequently the subject of post-harvest maturation is of importance. It is reported

* In Nyasaland Up-to-Date is said to store " extremely badly ".

from the tropics that seed of lettuce, celery, celeriac and cabbage improves in germination after storing for some months. In Kenya it is stated that lettuce seed requires a maturation period of about six weeks, whereas seeds of beans, peas and cauliflower germinate readily shortly after harvest and need no " after ripening ". Work in the U.S.A. has shown that cucumbers and pumpkins undergo a " weak germination " or after-ripening period of about six weeks, whereas carrots, peppers and tomatoes gave no indication of having a dormant period (28) The storage of seed in air-tight containers is not recommended unless the seed has had its moisture-content reduced to 6-9 per cent.

Research on the longevity of temperate vegetable seed in the tropics has been carried out in Hawaii, where Akamine (2) studied the effect of temperature and humidity on the viability of stored seeds, including beans and lettuce. It was found that both low relative humidities of 15-45 per cent. at ordinary room temperatures of 71-80° F. and low temperatures of 45-50° F. at ordinary relative humidities of 64-73 per cent. constituted excellent conditions for longevity of stored seed. A combination of controlled humidity and controlled temperature increased viability further.

(*o*) **QUESTION**

i. Are germination tests and field trials carried out under qualified supervision ?
ii. What are the methods and standards ?

(*o*) **REPLY**

Replies indicate that routine germination tests for vegetable seeds are by no means general in the tropics. In Kenya there is a Seed Testing Station in charge of the Plant Pathologist, the testing methods employed being those of the Seed Testing Station of the National Institute of Agricultural Botany, Cambridge. In Hawaii the methods and standards used are those of the Federal Seed Act of the U.S.A.

(*p*) **QUESTION**

i. Are there regulations controlling seed production ?
ii. How and to what extent are they enforced ?
iii. How have they affected the standard and quantity of production and trade ?

(*p*) **REPLY**

Except in Tanganyika, where there are regulations protecting the bean-seed industry, there appear to be no regulations in the tropics (1945) for controlling seed production. In Kenya a Bill was introduced (1947) which sought to improve the standard of the internal seed supplies of the Colony, to protect buyers against being supplied with seed of unknown origin and quality, and to build up a reputable export trade in flower and vegetable seed, which experience has shown can be produced in the country.

SOME CONCLUSIONS

(1) Evidence shows that, by using the wide range of altitudes available, seed of many so-called European or temperate-region vegetables can be produced successfully in several tropical regions. Apart from the standpoint of the tropical agriculturist, this knowledge is of value to temperate region plant breeders and seedsmen who could accelerate the seed production of new varieties by : (i) taking crops in the tropics during the temperate region winter, thereby saving a season, and (ii) exploiting the shorter sowing to harvest period of the tropics where biennials will seed in about a year. The lower cost of labour in most tropical countries and the shorter time in which seed crops can be raised would largely offset the cost of such a plan.

(2) One of the most interesting, and valuable, items of information in the replies is the statement that in the Kenya highlands, where the day-length is about twelve hours throughout the year, every kind of temperate vegetable so far tested, including long-day kinds, can be induced to flower and set seed by planting at high elevations, up to 10,000 ft. above sea level (see (*e*) reply). This suggests that some accepted theories concerning the minimum photoperiod essential to induce seeding in certain long-day plants may need reconsideration.

(3) It is remarkable that so few locally acclimatized varieties of temperate vegetables have been developed in the tropics, even where such vegetables have been grown for many years. The converse process of adapting tropical and sub-tropical crops to temperate zones has, on the other hand, progressed. Some tropical varieties of so-called European vegetables, e.g. peas, beans and cucurbits, are said to show superior disease-and-drought-resistance over imported kinds and may therefore be of value to plant-breeders elsewhere (see paragraph (*h*) iii.). Plant-breeders in the tropics might well use temperate varieties to introduce better eating qualities into some of the tropical vegetables, e.g. cucurbits.

(4) There is need for research into : (i) methods of storing roots and tubers in the tropics, more especially potatoes (*Solanum*), a crop of increasing importance in native diet ; (ii) the improvement of the indigenous and acclimatized vegetables of the tropics (see Appendix II) by breeding and selection ; (iii) the breeding and selection of tropical varieties of the principal temperate region vegetables, particularly root crops rich in sugar and carotene ; (iv) the unexplained sterility and low fertility of some varieties of temperate vegetables in the tropics (see (*j*)) ; (v) the pollination and necessary spatial isolation of vegetable seed crops grown in the tropics.

(5) Legislation would appear to be needed in many tropical countries to protect the grower and buyer by providing for the testing of seeds offered for sale, and there would also appear to be room for considerable improvement in the methods of seed storage used by seed merchants in the tropics.

(6) Investigations into the production of temperate region vegetable seeds has been discontinued in most tropical countries now that imported seed is again available. In East Africa the successful war-time investigations into vegetable seed production has been largely instrumental in initiating what appears to be a promising export industry in vegetable and flower seeds. There is a growing demand for temperate region vegetables, such as cabbage, carrots and peas, amongst indigenous people in parts of the tropics which should lead to an increasing demand for good, cheap vegetable seed, preferably locally produced.

BIBLIOGRAPHY

1 ADLER, R. (1940). The nature of short-day plants (transl.). *Forschungsdienst*, **9** : 332-67, bibl. 26. [H.A.,* **11** : 357.]

2 AKAMINE, E. K. (1943). The effect of temperature and humidity on viability of stored seed in Hawaii. *Bull. Hawaii Agric. Exp. Stat.*, **90**, pp. 23, bibl. 25.

3 BARKER, J. (1943). The part played by legumes in the diet of the Nyasaland African. *E. Afr. Agric. J.*, **8** : 212-8.

4 BARNES, H. (1943). Growing vegetables for seed. *Qd. agric. J.*, **57** : 84-9.

5 BARTON, L. V. (1935). Storage of vegetable seeds. *Contr. Boyce Thompson Inst.*, **7** : 323-32, bibl. 23.

6 BATEMAN, A. J. (1946). Genetical aspects of seed-growing. *Nature*, **157** : 752-5, bibl. 17.

7 ———— (1947). Contamination of seed crops. I. Insect pollination. *J. of Genet.*, **48** : 257-75, bibl. 8.

8 BOSWELL, V. R. and JONES, H.A. (1941). Climate and vegetable crops. *U.S.D.A. Yearbook 1941*, pp. 373-99, bibl. 32.

9 CAMPBELL, W. M. and EVANS, G. (1945). Experiments in the use of potato eyes for seed. *J. roy. hort. Soc.*, **70** : 142-6. [H.A., **15** : 1,108.]

* Horticultural Abstracts.

10 Cox and Starr. Seed production and marketing. John Wiley, New York, 1927, pp. 450.
11 Crane, M.B. and Thomas, P. T. (1942). Growing brassicas for seed. *Gdnrs' Chron. Lond.*, **112** : 140.
12 Dalziel, J. M. The useful plants of West Tropical Africa. Crown Agents for the Colonies, London, **1937**, pp. 612.
13 Glegg, C. G. (1945). Native foodstuffs in Tanganyika. *Trop. agric. Trin.*, **22** : 32-8, bibl. 3.
14 Greenway, P. J. (1945). Origins of some East African food plants. *E. Afr. agric. J.*, **10** : 34-9, 115-9, 177-80, 251-6, **11** : 56-63, bibl. 77.
15 Haskell, G. (1943). Spatial isolation of seed crops. *Nature*, **152** : 591-2, bibl. 16. [H.A., **14** : 167.]
16 ———— (1944). The pollination and spatial isolation of vegetable seed crops. *Northw. Nat.*, March and June, **1944**, pp. 34-44, bibl. 18. [H.A., **15** : 131.]
17 Hawkins, F. (1944). Production of seeds of temperate vegetables in East Africa. *E. Afr. agric. J.*, **9** : 196-202, bibl. 9.
18 Herklots, G. A. C. Vegetable cultivation in Hong Kong. Hong Kong, 1947, pp. 208.
19 Hill, A. G. G. (1940). Can seeds of European vegetables be produced successfully in the tropics ? *E. Afr. agric. J.*, **5** : 476-8.
20 ———— (1942). Vegetable seed growing in East Africa. *Ibid.*, **8** : 15-20, bibl. 13.
21 ———— (1946). The selection and improvement of food plants in relation to better nutrition. *Ibid.*, **12** : 125-7.
22 Joachim, A. W. R. *et al* (1938-39). The analysis of Ceylon foodstuffs, IV and VII. *Trop. Agriculturist*, **90** : 17-21, bibl. 10 ; **93** : 336-42, bibl. 6.
23 Kinman, C. F. and McClelland, T. B. (1916). Experiments on the supposed deterioration of varieties of vegetables in Porto Rico, with suggestions for seed preservation. *Bull. Porto Rico Agric. Exp. Stat.*, 20, pp. 30.
24 Macmillan, H. E. Tropical planting and gardening. *Macmillan, Lond*, 1935, pp. 560.
25 Millthorpe, F. L. and Horowitz, B. (1943). The effect of length of day and temperature on the flowering, seed production and growth of vegetables. *Agric. Gaz. N.S.W.*, **54** ; 53-7.
26 Moreau, R. E. (1944). The climatic background to the problem of potato varieties for East Africa. *E. Afr. agric. J.*, **9** : 127-35, 203-12, bibl. 72.
27 Ochse, J. J. Vegetables of the Dutch East Indies. Buitenzorg, 1931, pp. 1,005.
28 Odland, M. L. (1937). Observations in dormancy in vegetable seeds. *Proc. Amer. Soc. hort. Sci.*, **35** : 562-5, bibl. 5.
29 Purseglove, J. W. (1943). Some Uganda vegetables. *E. Afr. agric. J.*, **9** : 25-8, 98-101, bibl. 10.
30 Thomas, P. H. (1944). The harvesting, threshing and cleaning of vegetable seeds. *Tasm. J. Agric.*, **15** : 10-14.
31 Wood, R. C. *et al* (1936). Cauliflower cultivation in the tropics. *Trop. Agric. Trin.*, **13** : 218-20. [H.A., **6** : 885.]
32 [Imp. Agric. Bur.] The production of seed of root crops and vegetables. *Joint Publ. imp. Agric. Bureaux*, **5**, **1943**, pp. 78-88, bibl. 13.
33 [Kenya Dept. Agric.] *Report of vegetable seed production in Kenya during 1943.* Kenya Dept. Agric., **1944**, pp. 5, mimeographed.
34 [John Innes Res. Inst.] *Fifty-fifth Ann. Rep. John Innes Hort. Inst.* 1944, pp. 24.
35 ———— *Fifty-sixth Ann. Rep. John Innes Hort. Inst.* **1945**, pp. 28.
36 [Minist. Agric. Lond.] The threshing of grass, root and vegetable seed crops, *Bull. Minist. Agric. Lond.*, **130**, **1945**, pp.20.
37 [Puerto Rico Agric. Exp. Stat.] *A. R. Puerto Rico Agric. Exp. Stat., Rio Piedras*, **1942-43, 1944**, pp. 59.
38 [Ceylon Dept. Agric.] *Administ. Rep. Acting Dir. Agric., Ceylon*, **1943**, pp. 18.
39 ———— *Administ. Rep. Acting Dir. Agric., Ceylon*, **1944**, pp.23.
40 [Hawaii Agric. Exp. Stat.] *A. R. Hawaii Agric. Exp. Stat.*, 1940, pp. 94.
41 ———— *A. R. Hawaii Agric. Exp. Stat,*. **1941-42**, pp. 149.

APPENDIX I

Some temperate region vegetable varieties grown in various tropical countries.

BEETROOT

Barbados :	Detroit Dark Red, Eclipse, Globe.
British Guiana :	Detroit Dark Red, Early Blood Turnip.
Gold Coast :	Globe (Sutton's), Improved Dark Red (Starke Ayre's), Cape Market, Union Globe.
East Africa :	Early Wonder, Crimson Globe, Early Egyptian Flat.
Hong Kong :	Globe (Sutton's).
Mauritius :	Eclipse.
Nyasaland :	Egyptian, Crimson Globe, Eclipse.
St. Helena :	Crimson Globe.
Trinidad :	Detroit Dark Red and Dark Red Egyptian (Maule's).
Zanzibar :	Crimson Globe, Egyptian Turnip-rooted, Crosby's Egyptian, Red Ball (Burpee's).

BEANS

Barbados :	Bountiful, Kentucky Wonder.
Gold Coast :	Dwarfs: Plentiful (Sutton's), Premier (Sutton's), Bountiful (Starke Ayre's), U.S.D.A. Alabama Nos. 1, 18 and 25. Climbing: Alabama, Earliest of All (Sutton's), July Climbing Masterpiece (Carter's), Early Warwick. Lima: American Dwarf, Bush (Henderson's).
East Africa :	Canadian Wonder, Rose Coco, Small White Boston, Abundance etc.
Hong Kong :	Canadian Wonder (dwarf), Kentucky Wonder, Bountiful, Golden Wax-pod (climbing).
Mauritius :	Dwarfs: Victory, Long Tom, Wax-pod, Canadian Wonder. Climbing: Abundance, Everbearing, Wax-pod, Scarlet Runner.
Nyasaland :	Canadian Wonder, Khaki, Scarlet Runner, Painted Lady (climbing), Broad-bean, Improved Long Pod.
St. Helena :	Canadian Wonder, Victory, Danubie, Otenache, Early Warwick, Montenegro, Scarlet Runner, Broad-bean, Aquadulce.
Trinidad :	Kentucky Wonder, climbing (Maule's); King of the Garden lima, climbing (Maule's).
Zanzibar :	Dwarfs: Canadian Wonder, Victory, Long Tom. Climbing: Boston White Haricot, Epicure, Abundance, Sugar, Haricot de Soissons, Haricot de Suisse Blanc. Lima: Bush (Burpee's), Giant-podded pole (Burpee's), Popondo, Moki, Pebugale.

CABBAGE

Barbados :	Danish Ball-Head, Late Flat Dutch, Charlestone Wakefield etc.
British Guiana :	Flat Dutch.
East Africa :	Drumhead vars., Savoy vars., Sugar Loaf, Early Jersey Wakefield, Cape Spitzkohl, Ellam's Early, Ox-heart, First and Best.
Gold Coast :	Pride of Market (Sutton's), Pride of India, Early Drumhead, Premium Flat Dutch (Burpee's), Improved Winningstadt, All Season (Starke Ayre's), Earliest Savoy, Flowers of Spring, Eclipse Drumhead, Copenhagen Market, Best of All, All Heart.
Hong Kong :	Golden Acre, All Head Early (Burpee's), Harbinger, Alpha, Early Jersey Wakefield (Ferry Morse), Succession (Yates), Utility (Yates), Copenhagen Market (Ferry Morse) Drumhead (Ferry Morse), Enhuizen Glory (Yates), Flower of Spring, Mein's No. 1, Dennis Ball Head.
Mauritius :	Cape Spitzkohl, Savoy, Prize Drummond, Castle.
Nyasaland :	Surehead, Sugar Loaf, Drumhead, Main, Spitzkohl.
St. Helena :	Copenhagen Market, Robinson's Drumhead, Ox-heart, Spitzkohl.

CABBAGE—*cont.*

Trinidad :	Jersey Wakefield (Maule's), Early Flat Dutch (Maule's), Drumhead (Maule's).
Zanzibar :	Succession (Burpee's), Pride of India, Drumhead vars., Sugar Loaf, Early New York, Winningstadt, Early Jersey Wakefield, All Head Early, Late Flat Dutch, Special Succession All Head.

CARROT

Barbados :	Chantenay, Oxheart, Danvers Half-long.
British Guiana :	Imperator, Danvers Half-long.
Gold Coast :	Early Gem (Sutton's), New Intermediate Red, Champion Scarlet Horn, Nantes (Starke Ayre's), Early Cape Market, Chantenay, Early Horn.
East Africa :	Chantenay, Early Shorthorn.
Hong Kong :	Intermediate, Favourite (Sutton's), Early Gem, Champion Scarlet Horn (Sutton's).
Mauritius :	Nantes, Chantenay.
Nyasaland :	Chantenay, Long Red.
St. Helena :	Chantenay.
Trinidad :	Chantenay, Danvers Half-long (Maule's).
Zanzibar :	Early French Horn, Chantenay, Inimitable Forcing, Early Nantes, James's Intermediate, Long Red Surrey, Oxheart, Champion Scarlet Horn, Short Horn.

CAULIFLOWER

Temperate region cauliflower varieties do not normally thrive in the tropics and so are seldom grown, except at high elevations, or during the cool season. The so-called tropical varieties from India, such as Early Benares, Early Patna and Early Market (Sutton's), are now in general cultivation in many parts of the tropics, e.g. Barbados, British Guiana, Gold Coast, East Africa (lowlands), Hong Kong (hot season), Nigeria, Trinidad and Zanzibar.

East Africa :	In highlands Southern Cross and Snowball.
Hong Kong :	For early sowing : First Crop and Early Giant (Sutton's). For October sowings : All the Year Round, Burpeena, Walcheren, Magnum Bonum and Early London.
Mauritius :	Local strains derived from Alger and Le Normand.
Nyasaland :	Southern Cross, Early Snowball.
St. Helena :	All the Year Round.

CELERY

British Guiana :	Easy Blanching.
Gold Coast :	White Gem (Sutton's).
East Africa :	Grove White, Early White.
Hong Kong :	White Plume (Henderson's), Golden Self-Blanching, Solid White, Giant White.
Nyasaland :	Giant White.
Trinidad :	Golden Plume (Henderson's).
Zanzibar :	White Gem, Golden Self-Blanching, Grove White.

CUCUMBER

British Guiana :	White Spine.
Gold Coast :	White Gem (Sutton's), Long Green Prolific, Every Day, New Model (Starke Ayre's), Ridge.
East Africa :	Long Green Ridge, Telegraph.
Nyasaland :	Early White, Long Green.
St. Helena :	Cool and Crisp.
Zanzibar :	Pola Khira, Telegraph, Japanese Climbing, Early Fortune, Long Green Athens, Prolific Ridge (Sutton's).

LEEK

East Africa :	Musselburgh, London Flag.
Hong Kong :	Broad London Flag, Musselburgh.
Mauritius :	Italian Giant.
Nyasaland :	Broad London Flag.
St. Helena :	Giant Musselburgh.
Zanzibar :	Musselburgh, London Flag.

LETTUCE

Barbados :	Mignonette, Black-seeded Simpson.
British Guiana :	Mignonette, Black-seeded Simpson.
Gold Coast :	Cabbage varieties : A1 (Sutton's), Supreme, Black-seeded Simpson, New York Special (Starke Ayre's), Immensity (Kirchoff's), Crystal Cabbage, Imperial 847. Cos varieties : Little Gem (Sutton's), Lemon Queen (Dobbie's), White Summer.
East Africa :	Iceberg, Mignonette, Big Boston, New York Special, Early Paris Market.
Hong Kong :	Cabbage varieties : Mignonette, All the Year Round, Majestic, Heartwell, Tom Thumb, Favourite, New York Imperial No. 615, Neapolitan, Iceberg. Cos varieties : Little Gem, Superb White.
Mauritius :	Succrine, Mignonette, Webb's Wonderful, Mammoth Butter, Iceberg.
Nyasaland :	Iceberg, London White, New York, Mammoth Butter.
Trinidad :	Mignonette (Henderson's), Imperial 847, Iceberg (Maule's), Early Paris, Great Lakes, Wayahead.
Zanzibar :	Mignonette, Early Paris Market, Iceberg, Golden Ball, Black-seeded Simpson, Big Boston, White Cos (Pen's), Immensity, New York, Mammoth Butter, London White Cos, Cos All Heart, Webb's Wonderful.

ONIONS

British Guiana :	Yellow Bermuda.*
Gold Coast :	Brown Globe, Kirchoff's Mammoth, Red Globe, Early Flat (Starke Ayre's), Yellow Cape, Yellow Bermuda.* [Sutton's Tropical also grown.]
East Africa :	Crystal Wax, Early White Grand, Red Bombay, Red Creole, Yellow Bermuda.* [The short-day Indian onion of the Bombay type is the kind commonly grown for market in the main onion-growing areas.]
Hong Kong :	White Bermuda,* Early Cape Flat Yellow.
Nyasaland :	Brown Spanish, Silver King, Cape Yellow, Prize-taker.
St. Helena :	Cape Yellow Flat, Yellow, Red and White Bermuda.*
Trinidad :	Yellow Bermuda* (Prieto's), Yellow Globe Danvers.
Zanzibar :	White Bermuda,* Madeira Sebola Salsia, Australian Brown, White Leviathan. [The short-day kind, White and Red Bombay and Red Patna also grown.]

PARSNIPS

East Africa :	Hollow Crown, Intermediate, Tender and True.
Zanzibar :	Hollow Crown, Butter and Cream.

PEAS

Gold Coast :	Duchess of York (Sutton's), Productive Marrowfat, South Australian Collegian, Mauritius, Creole.
East Africa :	Alderman, Senator, Green Feast, Harrison's Glory, Mauritius Petit Pois.
Hong Kong :	Duke of Albany, V.C. (Sutton's), Quite Content, Telephone, Green Feast, Utility.
Mauritius :	Green Feast (dwarf), Black-eyed Susan, Stratagem, Telephone, Pride of Market. [A successful local pea known as Petit Pois Pigeon, probably of Indian origin in first place, deserves to be better known in those parts of the tropics where difficulty is experienced in growing the common garden pea.]

* The seed of these Bermuda varieties is not produced in Bermuda but in the Canary Isles and California.

PEAS—*cont.*

Nyasaland :	Stratagem. Black Eye.
St. Helena :	Stratagem, Emperor.
Zanzibar :	Mammoth Luscious, Mauritius, Alderman, Matar, Black-eyed Susan.

RADISH

Barbados :	White Icicle.
British Guiana :	White Icicle, Scarlet Globe.
Gold Coast :	Early Rose (Sutton's), Early Red Globe, White Turnip, Long Scarlet, Winter, China Rose, Olive, Sparkler.
Hong Kong :	French Breakfast, Earliest of All , Rapid Red, Icicle.
Mauritius :	Giant Globe.
Trinidad :	Scarlet Globe (Henderson's), French Early Breakfast.
Zanzibar :	Scarlet Gem, Sparkler, French Breakfast, Scarlet Globe, Chinese White, Contai Long.

TOMATO

British Guiana :	Brimmer, Marglobe, Early Market.
Gold Coast :	Best of All, Bonny Best, Rutgers, Victor, John Baer, Bay State, Marglobe, Prolific, Prince of Wales.
East Africa :	Bonny Best, Tatura Dwarf Globe, Ailsa Craig, John Baer, Marglobe, Marvel, Stone, Sunrise, Best of All, Early Market, Welt Kugel.
Hong Kong :	Earliana, Earliwinner (Yates), Best of All, Prosperity (Yates), Everyday, Abundance, Bonny Best, Sunrise, Marglobe, Ponderosa, Pritchard, Burwood Prize, Norton, June Pink, Jubilee.
Mauritius :	Marglobe, Ponderosa, Beauty.
Nyasaland :	Marglobe, Bonny Best, Sunrise, Best of All.
St. Helena :	Ailsa Craig, Yellow Plum, Marglobe, Livingstone Core-less.
Trinidad :	Bonny Best, Marglobe, Winsall (Henderson's).
Zanzibar :	Ailsa Craig, Best of All, Ponderosa, Marglobe, Golden Queen, Beauty, Glovel, Oxheart, Bonny Best, Earliana, Break O'Day, Rutgers.

TURNIP

Barbados :	Purple-Top, White Globe.
British Guiana :	Early Snowball, Milan, Strap Leaf, Mauritius Purple-Top.
East Africa :	Golden Ball, Milan Early White, White Globe.
Hong Kong :	Early Snowball, Green-Top White, White Stone.
Mauritius :	Local strain of French turnip.
Nyasaland :	Snowball, Purple-Top, Red-Top.
St. Helena :	White Globe, Snowball.
Trinidad :	Purple-Top, White Globe.
Zanzibar :	White Country, Early Snowball, Golden Ball, Purple-Top, White Globe.

APPENDIX II

A selection of indigenous and naturalized plants used as vegetables in various tropical countries.

(Parts eaten : L = leaves ; R = roots, tubers or bulbs ; S = seeds ; F = fruit.)

BRITISH GUIANA

Amarantus sp., caterpillar calalu. L.
Hibiscus esculentus, okra. F.
Phytolacca octandra, French calalu. L.
Xanthosoma atrovirens, Indian kale. L.

CEYLON

Alternanthera sessilis, mukunawenna. L.
Amarantus paniculatus, tampala. L.
Dioscorea spp. R.
Hibiscus esculentus, bandakkas. F.
Ipomœa aquatica, kan-kun. L.
——— *bona-nox*, moon flower, al-anga. Calyces eaten.
Manihot utilissima, cassava. R.
Momordica charantia, bitter gourd. F.
Moringa oleifera, murungas. F and L.
Sesbania grandiflora, agathi. L and petals.
Talinum spp., spinach. L.

EAST AFRICA

Acalypha ciliata. L.
Adansonia digitata, baobab. L.
Allium cepa, onion. L and R.
Amaranthus spp., Love-lies-bleeding. *A. blitum, A. caudatus, A. graecizans, A. patulus, A. spinosa*. L.
Arachis hypogaea. L and S.
Basella alba, Ceylon spinach. L.
Bidens pilosa, black jack. L.
Cajanus cajan, pigeon pea. S.
Capsicum spp., bird and red pepper. *C. annuum, C. frutescens*. L, young shoots and F.
Celosia spp., *C. schweinfurthiana, C. trigyna*. L.
Chenopodium album, goose foot. L.
Cleome spp., bastard mustard. *C. hirta, C. monophylla, C. strigosa*. L.
Cocos nucifera, coconut. Growing point and F.
Coleus spp., Kaffir potato. *C. barbatus, C. esculentus*. R.
Colocasia antiquorum, taro, eddoes. L and R.
Corchorus spp., jute, *C. olitorius, C. trilocularis*. L.
Cucumis sativus, cucumber. L and F.
Cucurbita maxima, pumpkin. L and F.
Curcuma longa, turmeric. R.
Dioscorea spp., yams. *D. abyssinica, D. alata, D. bulbifera, D. triphylla* var. *dumetorum*. R.
Dolichos lablab, hyacinth, bonavista or Indian butter bean. S.
Erythrococca kirkii. L.
Fagara olitoria. L.
Gynandropsis gynandra, bastard mustard. L.
Hibiscus spp. *H. acetosella, H. cannabinus, H. intermedius, H. physaloides*. L.
Hibiscus esculentus, okra. L and F.
Ipomœa batatas, sweet potato. L and R.
Ipomœa reptans. L.
Justicia striata. L.
Lagenaria vulgaris, gourd. F.
Lobelia fervans. L.
Luffa spp., loofah. *L. cylindrica, L. acutangula*. F.
Lycopersicum esculentum, tomato. F.
Manihot glaziovii, ceara rubber. L.
——— *utilissima*, cassava. L and R.
Momordica charantia, bitter gourd. F.
Moringa pterygosperma, horse radish or drumstick tree. L and F.
Musa paradisiaca, plantain. F.
Phaseolus vulgaris, french or kidney bean. L and S.

EAST AFRICA—*cont.*

Phaseolus lunatus, Lima or Madagascar bean. S.
——— *mungo*, black and green gram. S.
Phoenix reclinata, wild date-palm. Young growing point.
Pisum sativum, pea. S.
Portulaca oleracea, wild purslane. L.
——— *quadrifida*. L.
Sesamum orientale, sesame, simsim. L and S.
Sesuvium portulacastrum, samphire. L.
Sphenostylis stenocarpa, yam bean. S.
Solanum melongena, egg-plant, brinjal. F.
Sonchus bipontinii. L.
Talinum cuneifolium. L.
Telfairea pedata, kweme or oyster nut. S.
Vigna unguiculata, cow-pea. L and S.
Voandzeia subterranea, bambarra ground-nut. S.
Zea mays, maize. Green cobs.

GAMBIA

Amarantus caudatus, spinach.
Capsicum sp., chillies.
Cucurbita sp., pumpkins.
Hibiscus esculentus, okra.
———*sabdariffa*, rozelle.
Ipomoea batatas, sweet potatoes.
Manihot utilissima, cassava.

HONG KONG*

Allium tuberosum, chinese chives; *Allium* sp., chinese onions.
Amarantus gangeticus, chinese spinach.
Apium graveolens, celery.
Benincasa cerifera, wax gourd.
Brassica alboglabra, chinese kale.
——— *chinensis*, chinese white cabbage and chinese flowering cabbage.
——— ——— var. *pekinensis*, Shantung or Pekin cabbage.
——— *juncea*, leaf-mustard cabbage.
——— *oleracea*, chinese kale.
Canavalia gladiator and *C. ensiformis*, sword beans. Pods eaten green.
Capsicum annuum and *C. frutescens*, peppers.
Colocasia antiquorum var. *esculenta*, taro.
Cucumis sativus, chinese cucumber.
Cucurbita moschata, chinese pumpkin.
Dendrocalamus sp., bamboo shoots. See also *Phyllostachys*.
Dioscorea esculenta and *D. alata*, yams.
Dolichos lablab, hyacinth bean.
Eleocharis dulcis, *E. tuberosa*, water chestnut. See also *Scirpus*.
Glycine hispida, soy bean.
Helianthus tuberosus, Jerusalem artichoke.
Hibiscus esculentus, okra.
Ipomœa batatas, sweet potato.
——— *reptans*, water spinach, swamp cabbage: two forms. L.
Lactuca sativa, chinese lettuce, two varieties. L, usually cooked.

* List compiled from :—Vegetable Cultivation in Hong Kong by G.A.C. Herklots, 1947.

HONG KONG—*cont.*

Lagenaria vulgaris, calabash. F.
Luffa cylindrica, *L. acutangula*, luffah. F.
Lycium chinense, chinese box thorn. L.
Maranta arundinacea, arrowroot. R.
Momordica charantia, bitter gourd. F.
Nelumbium nucifera, lotus. R.
Pachyrrhizus erosus, yam bean.
Phyllostachys edulis, bamboo shoots. See also *Dendrocalamus*.
Portulaca oleracea, purslane.
Pueraria hirsuta, kudzu vine. R.
Raphanus sativus, var. *longipinnatus*, chinese radish.
Sagittaria sagittifolia, arrowhead.
Solanum melongena, egg-plant.
Vigna unguiculata, cowpea.
Zea mays, maize, sweetcorn. Green cobs.

INDIA

Actinodaphne speciosa, elephant ear.
Allium cepa, onion. *A. ascalonicum*, shallot. *A. sativum*, garlic.
Amarantus gangeticus, kerrai or sag.
Arachis hypogaea, ground-nut, peanut.
Basella alba, Indian spinach.
Benincasa cerifera, ash pumpkin, white gourd.
Beta bengalensis, palak.
Brassica napus, rape sag.
Cajanus indicus, pigeon pea, dhal.
Canavalia ensiformis, sword bean.
Capsicum annuum and *C. frutescens*, chilli peppers, bell pepper.
Cicer arietinum, chick pea, Bengal gram.
Colocasia antiquorum, kachchi, arvi.
Cucumis sativus, pipingkai, native cucumber.
Cucurbita melo-pepo, squash, *C. maxima*, pumpkin, *C. moschata*.
Cyamopsis psoralioides, cluster bean.
Dioscorea aculeata, Goa potato.
Dolichos lablab, bonavist bean.
Glycine hispida, soya bean.
Hibiscus esculentus, okra, lady's finger.
Ipomœa batatus, sweet potato.
Lagenaria vulgaris, bottle gourd.
Lens esculenta, lentils.
Luffa acutangula, *L. aegyptica*, luffah, sponge gourd.
Momordica charantia, kerala or bitter gourd.
Moringa pterygosperma, horse-radish tree.
Phaseolus vulgaris, *P. lunatus*, *P. mungo*, various beans, grams etc.
Psophocarpus tetragonolobus, Goa bean.
Raphanus sativus, cabbage-radish. L.
Solanum melongena, egg-plant, brinjal.
——— *tuberosum*, potato.
Tacca pinnatifida, Indian arrowroot.
Trichosanthes anguina, snake gourd.
Vigna catiang, cowpea. *V. sesquipedalis*, asparagus bean.
Zea mays, maize, sweetcorn. Green cobs.

MAURITIUS

Brassica chinensis, brede de chine (vert et blanc), pe-tsai.
Capsicum spp., chillies.
Cucumis sativus, pipingkai, cucumber.
Cucurbita maxima, pumpkin. *C. melo-pepo*, squash.
Luffa spp., sponge gourds.
Lycopersicum esculentum, pomme d'amour, tomato.
Sechium edule, chou-chou. F and L.
Solanum nigrum, brede martin. L.
——— *melongena*, egg-plant, brinjal.
Vigna sesquipedalis, winged bean and *V. catiang*, cowpea.

NIGERIA, NORTHERN

Adansonia digitata, baobab, kuka. L.
Allium cepa, onion, albasa. *A. ascalonicum*, shallot, shafa.
Amarantus caudatus, native spinach, alayafu.
——— *viridis*, zaki banza.
Arachis hypogaea, groundnut, gyada.
Ceratotheca sesamoides, karkashi. L and S.
Corchorus olitorius, bush okra, turgunuwa, lalo. L.
Cucurbita pepo, pumpkin, goji.
Gynura cernua, baba hum. L.
Hibiscus esculentus, okra, kubewa.
——— *sabdariffa*, roselle, yakuwa.
Ipomœa batatas, sweet potato, dankali.
Lagenaria vulgaris, white pumpkin, kulubutu.
Lepidium sativum, garden cress, lapsur.
Maerua angolensis, cicuwa, chichiwa. L.
Manihot utilissima, cassava, rogo.
Moringa pterygosperma, horse-radish tree, zogalagandi.
Momordica balsamina, balsam apple, garahuni.
Plectranthus sp. (*Coleus dazo*) rizga. R.
Solanum melongena, egg-plant, yalo.
——— sp., bitter tomato, gauta.
Stylochiton dalzielii, gwandai, kunnan jaki. L.
Vernonia amygdalina, bitter leaf, shuwaka.
Vigna sinensis, cowpea, wake.
Vitex cienkowskii, dinkin, dinya. F and L.
Voandzeia subterranea, bambara ground-nut, gurjiya.
Xanthosoma sagittifolium, cocoyam, gwaza.

PUERTO RICO

Colocasia sp., malanga, cocoyam.
Dioscorea sp., yam.
Ipomœa batatas, batata, sweet potato.
Manihot utilissima, yuca, manioc, cassava.
Musa sp., plátano, plantain.
Sechium edule, chayote.
Solanum melongena, berenjenas.
Xanthosoma sp., yautía.

TRINIDAD

Allium spp., shallots, chives, Japanese bunch onions.
Amarantus spp., local spinach, bhaji.

TRINIDAD—*cont.*

Basella alba, poi spinach.
Brassica juncea, mustard.
Capsicum spp., hot peppers.
Cucumis sativus, native cucumber.
Cucurbita maxima, pumpkin.
Dolichos lablab, seme.
Helianthus tuberosus, Jerusalem artichoke.
Hibiscus esculentus, okra.
Lagenaria leucantha, gouge.
Lycopersicum sp., " native tomato ".
Nasturtium officinale, water-cress.
Phaseolus vulgaris, salad bean.
Raphanus sativus, morei radish.
Sechium edule, christophine.
Solanum melongena, egg-plant.
Vigna sesquipedalis, bodie.
Zea mays, maize.

ZANZIBAR

Amarantus spp., love-lies-bleeding, native spinach. L.
Celosia sp., cockscomb. L.
Cleome spp., spider flower. L.
Gynandropsis gynandra, bastard mustard. L.
Lycopersicum sp., native tomato. F.
Tacca involucrata, African arrowroot. R.

APPENDIX III

Meteorological Data

	Mean Maximum °F.	Mean Minimum °F.	Rainfall ins.	No. of days of rain.
KENYA: Turi Seed Farm, 7,700 ft. above sea level.	*	*	†	
January	77.0	48.9	1.46	5
February	79.9	48.5	2.33	8
March	78.3	52.0	5.30	14
April	74.8	53.2	6.05	17
May	73.9	52.6	5.02	19
June	72.6	51.2	3.95	17
July	70.5	49.4	5.87	21
August	70.1	50.0	5.78	21
September	71.7	49.6	3.18	14
October	72.4	50.3	2.21	14
November	75.3	52.8	3.15	17
December	76.1	49.9	2.79	11
Year	74.4	50.7	47.00	178

* 1946 only.

† 15 year average.

	Mean Maximum °F.	Mean Minimum °F.	Rainfall ins.	No. of days of rain.
KENYA: Equator, 9,062 ft. above sea level.				
January	67.9	45.8		
February	69.4	46.7		
March	68.8	47.4		
April	67.1	48.1		
May	65.4	47.8		
June	63.0	47.1		
July	59.8	46.5		
August	60.7	46.2		
September	64.2	46.2		
October	66.0	46.0		
November	64.8	46.8		
December	65.0	45.9		
Year	65.2	46.7		
INDIA: Nilgiris, 1944.				
January	76.8	42.0	2.61	3
February	79.0	45.2	1.89	8
March	81.3	48.1	5.36	10
April	82.4	55.2	4.15	10
May	82.1	57.8	3.08	13
June	75.0	56.9	6.84	20
July	70.3	55.6	5.39	24
August	74.9	53.0	5.82	16
September	75.7	55.5	7.03	19
October	75.7	53.6	6.36	19
November	69.7	52.2	8.71	22
December	73.3	45.8	3.00	9
Year	76.3	51.7	60.00	173
MAURITIUS: Réduit Exp. Stat., 900 ft. above sea level.				
January	82.4	70.1	10.25	
February	82.5	71.3	11.00	
March	82.0	70.2	11.80	
April	79.7	68.0	5.40	
May	76.1	64.0	4.20	
June	72.5	60.0	3.00	
July	71.6	60.1	2.75	
August	71.6	58.7	2.50	
September	73.2	60.0	1.75	
October	76.3	60.9	1.85	
November	79.7	64.8	2.30	
December	82.0	68.0	6.35	
Year	77.5	64.7	63.00	

APPENDIX IV

List of countries to which the questionnaire was sent.

Barbados
Bermuda
British Guiana
British Honduras
Ceylon
East Africa
  Kenya
  Tanganyika
  Uganda
Gambia
Gold Coast
Hawaii
India
  Baluchistan
  Bombay
  Kashmir
  Madras
  Punjab
  Sind
Mauritius
Nigeria
Nyasaland
Palestine
Puerto Rico
Sierra Leone
St. Helena
Trinidad
Zanzibar

ACKNOWLEDGMENTS

Grateful acknowledgment is paid to the various agricultural authorities who kindly provided information in response to the questionnaire and to Mr. F. R. Horne for his much appreciated gesture in writing the foreword.

Thanks are also due to the following individuals for information provided: F. Hawkins, T. H. Jackson, P. J. Greenway, A. S. Thomas, R. J. Lathbury, H. C. Thorpe, J. Moon, E. Baker, R. M. Nattrass and V. A. Beckley.